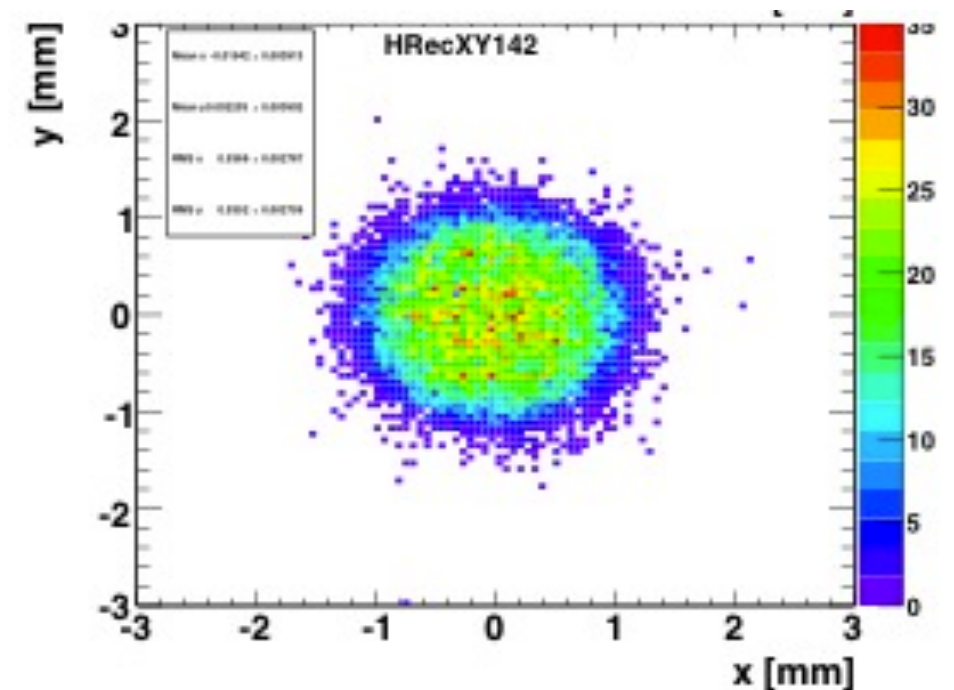
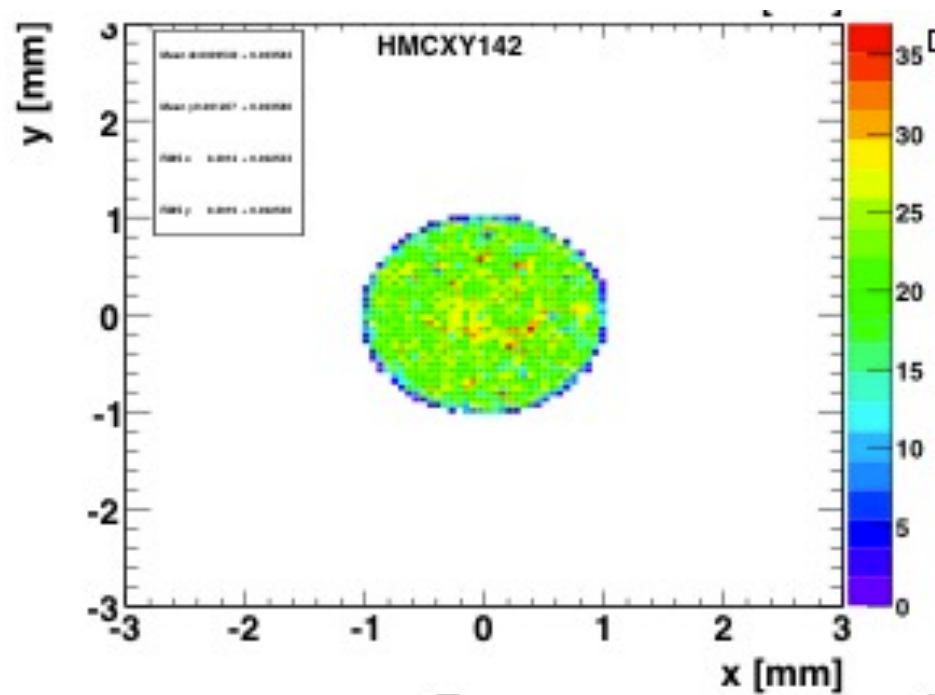


Target and collimators as constraints for tracking with GTK



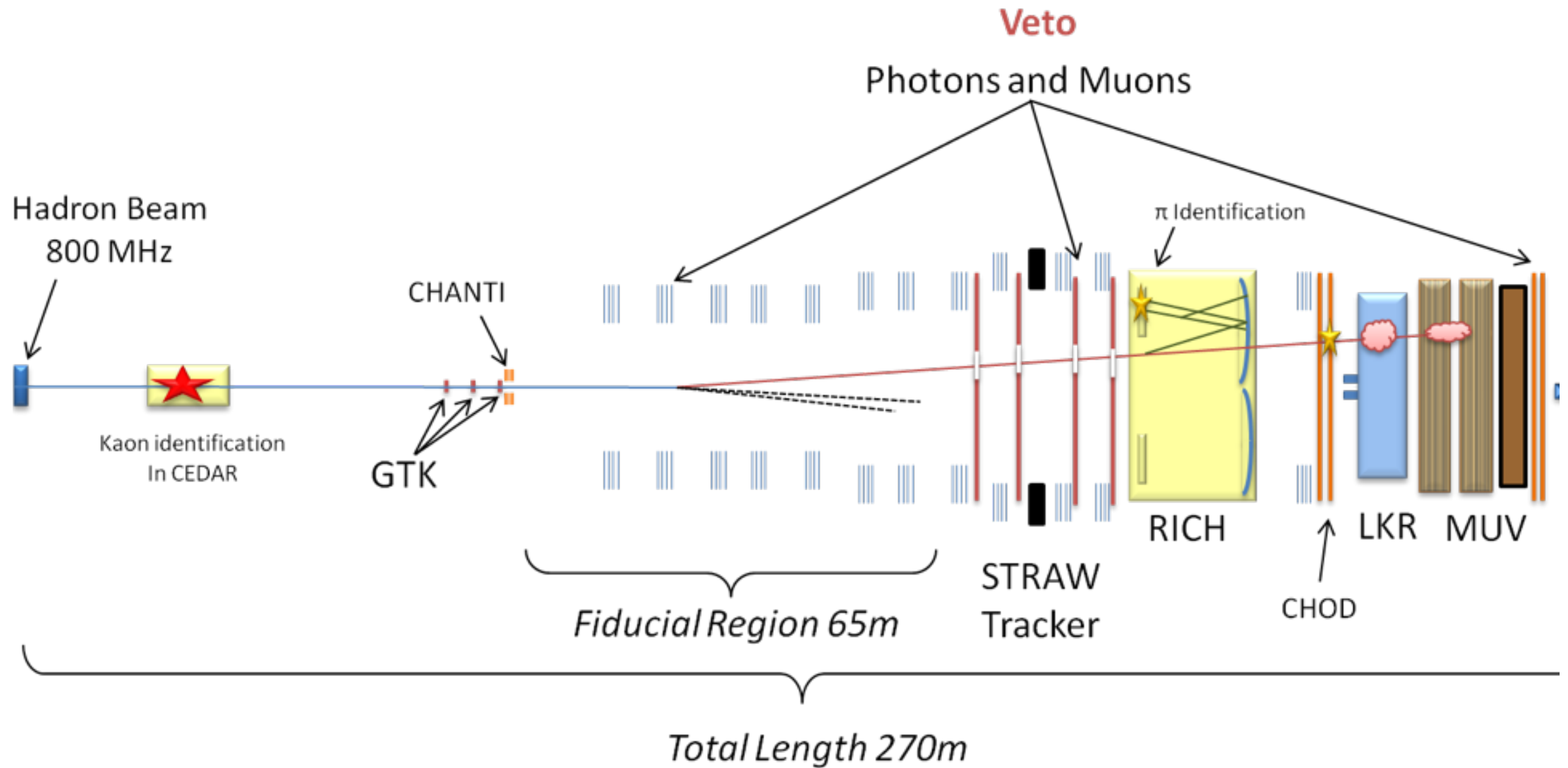
Postyn Smith
CERN, Geneva, Switzerland
Williams College
May 26, 2014

Goal of NA62

- Measure the decay of $K^+ \Rightarrow \pi^+ \nu \bar{\nu}$
- The probability of this decay is about 10^{-11}
- This will be the first experiment to measure such a rare decay of charged kaons
- The results will be compared to Standard Model estimates for the lifetime of top quarks to bottom quarks



Experiment Setup



Recall

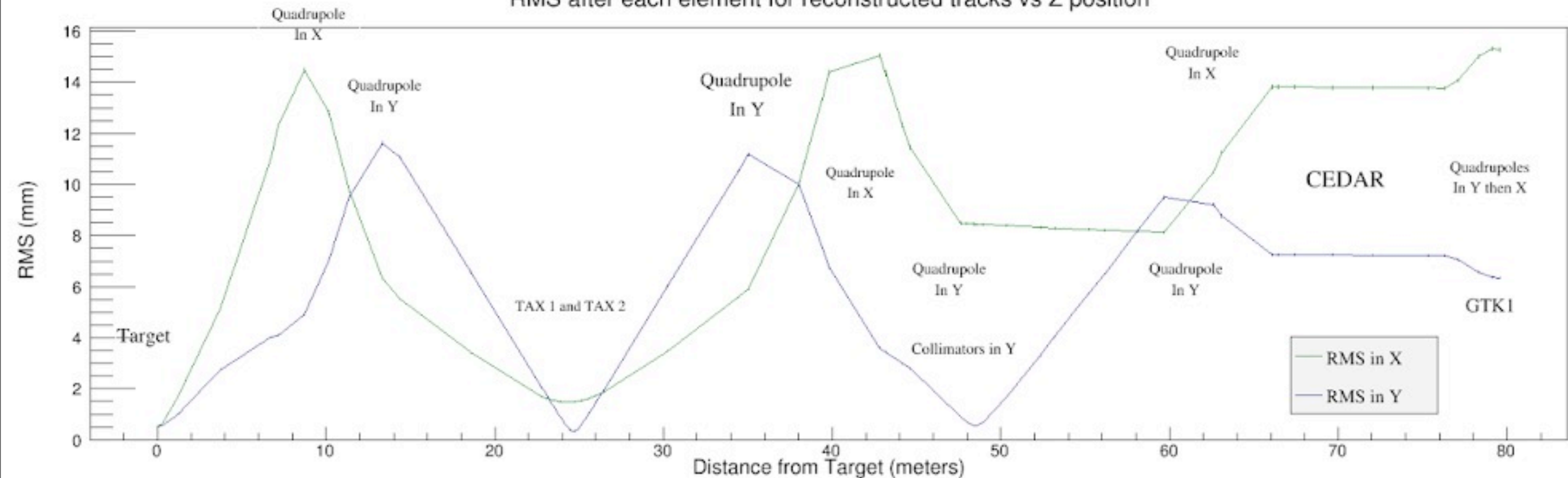
- The GTKs (GigaTrackers) are three silicon micro-pixel stations that measure the time, momentum, and thus direction of each particle in the beam before they enter the decay region
- The pixels are $300\text{ }\mu\text{m} \times 300\text{ }\mu\text{m}$ producing uncertainty in the reconstruction of the particle tracks.
- Given that the particles originated from the target and traversed all of the beam-line elements, by propagating the tracks backwards from GTK to the target, we can observe the inefficiencies of the GTK reconstruction

Outline

- Find the most “constraining” elements in the beam line
 - Number of tracks stopped at a given element
 - Difference in RMS of the beam spot in X and Y at a given element
- Compare no interaction with no interaction and enlarged elements
- Compare H₂ and N₂ for use in CEDAR (Cherenkov Differential counter with Acromatic Ring Focus)
- Prepare to implement a fit

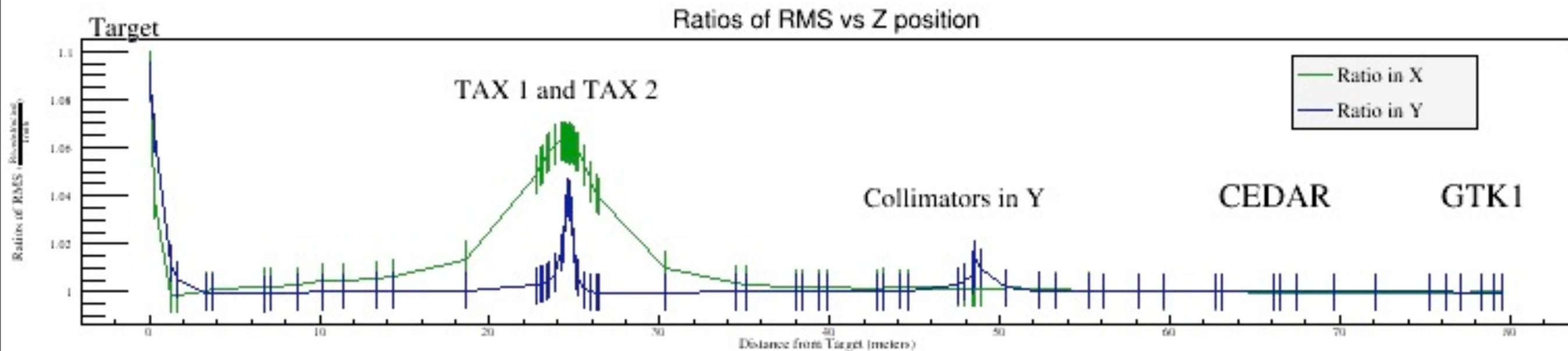
RMS in X and Y vs Z position

RMS after each element for reconstructed tracks vs Z position



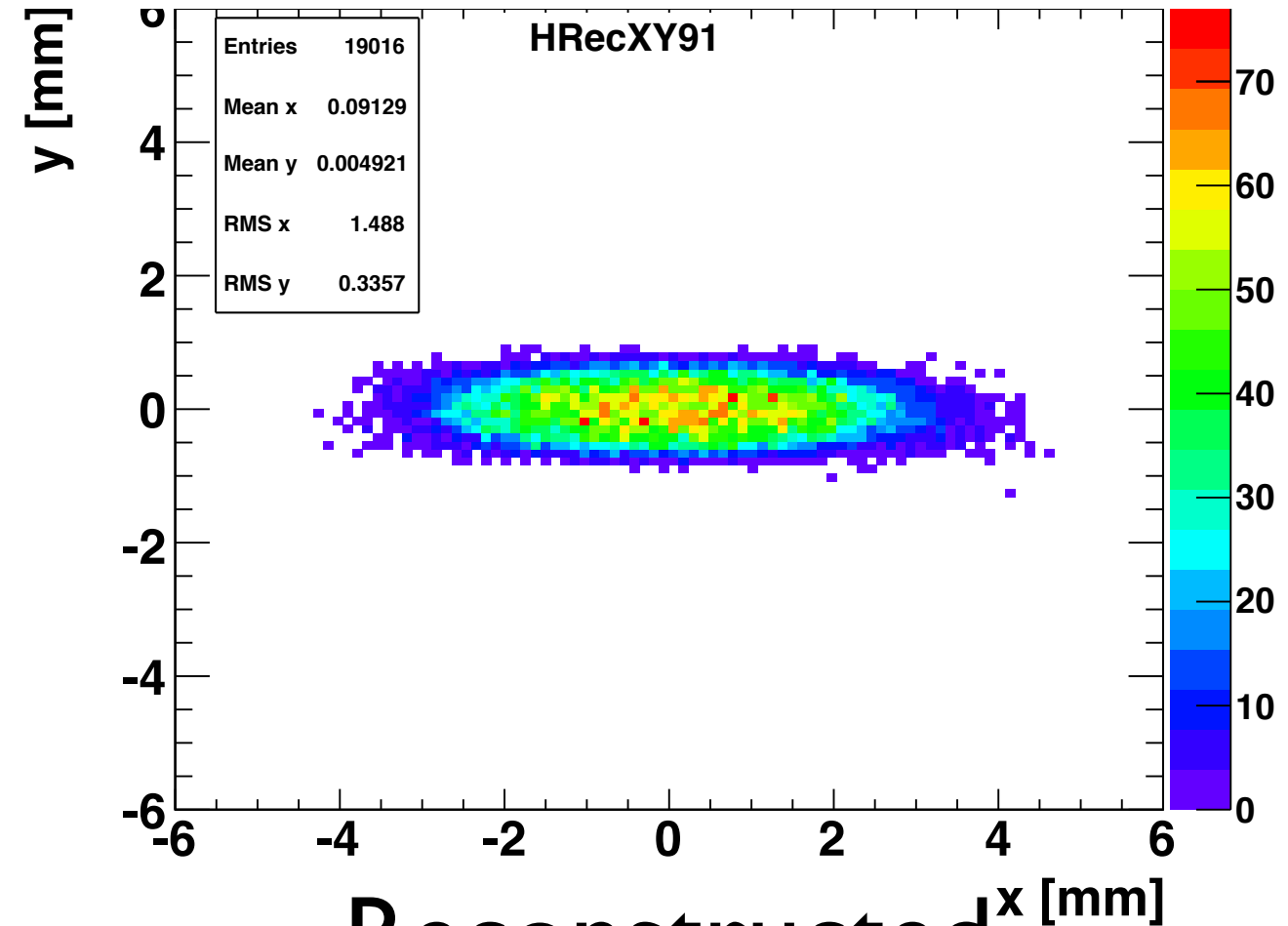
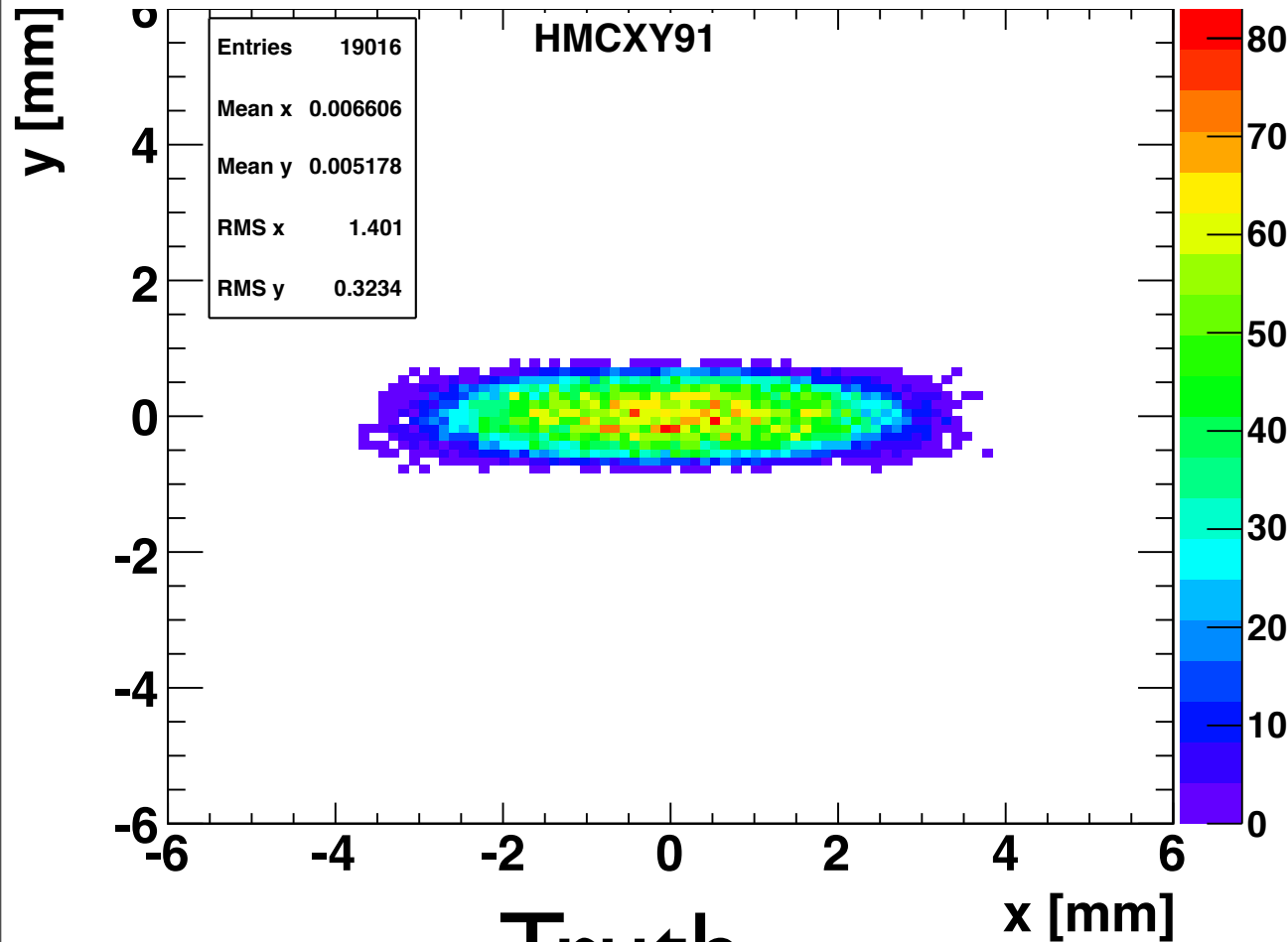
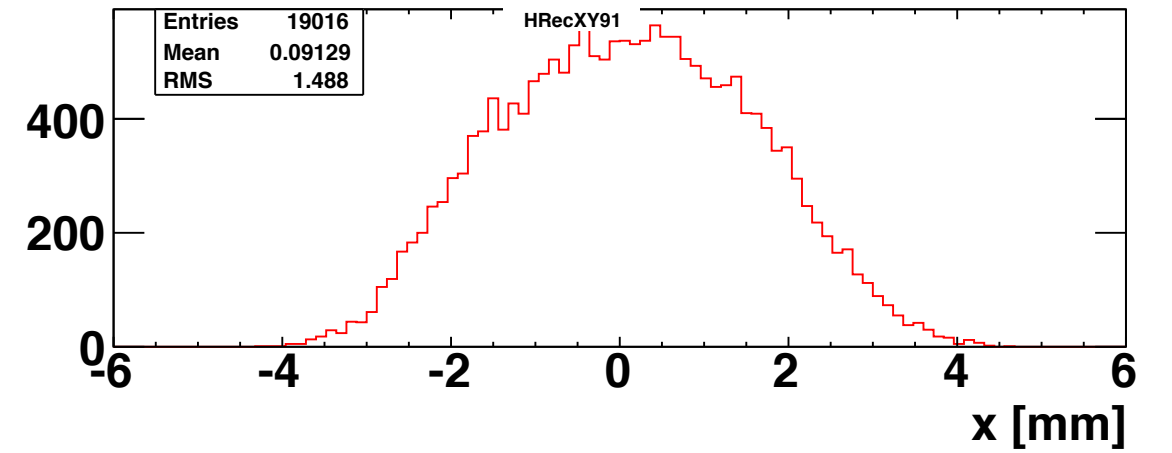
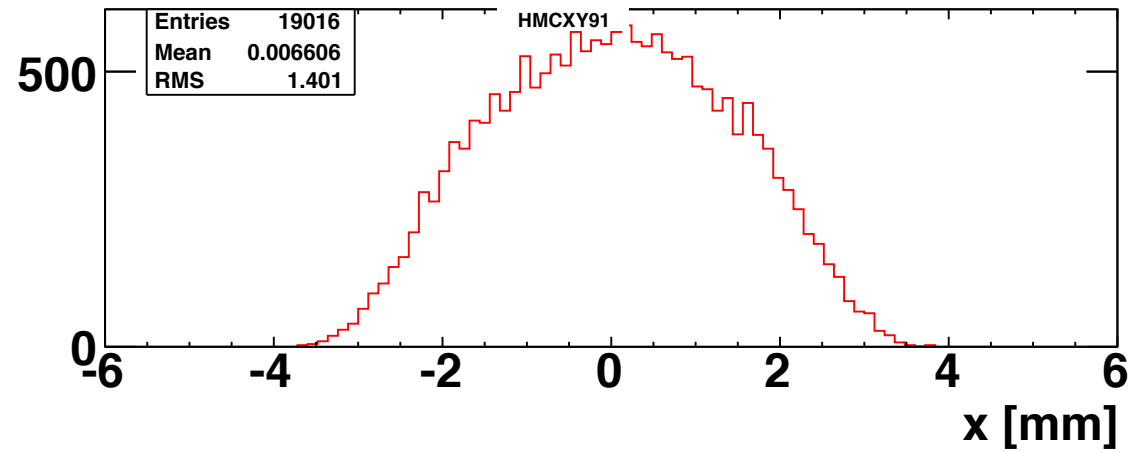
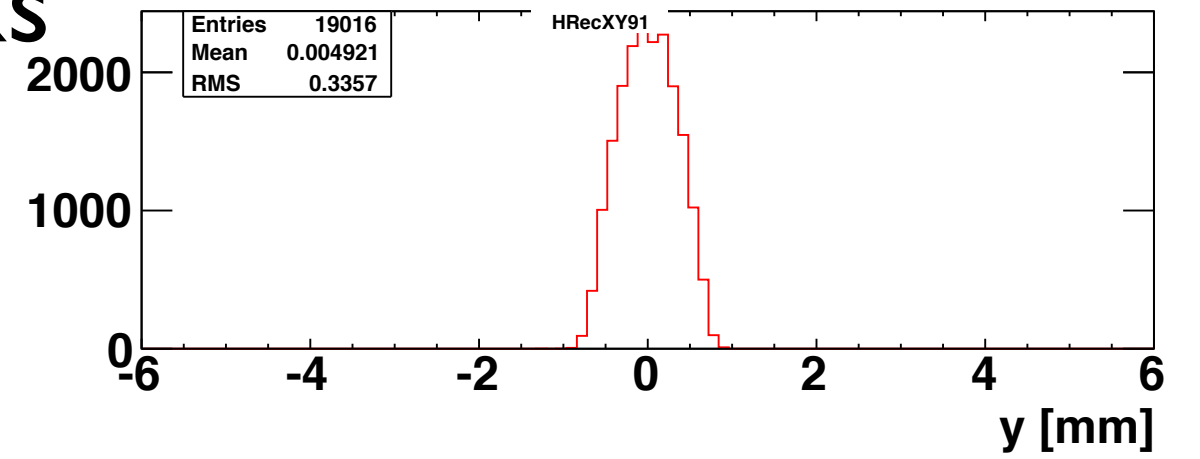
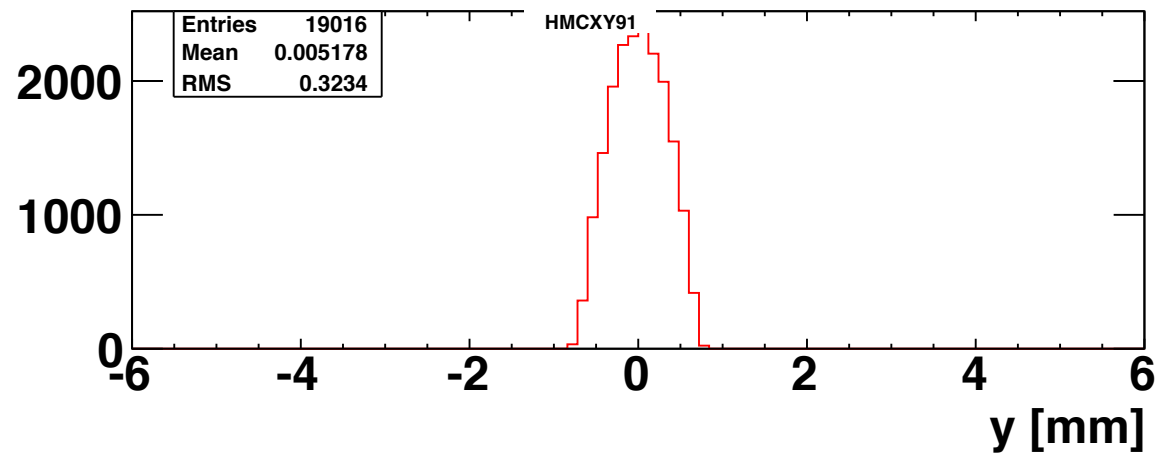
- The shape is consistent with what is expected
- When a quadrupole focus on one axis that causes the beam to defocus in the other direction
- The focus points are at the target, TAX, and collimators
- The beam runs parallel through the CEDAR
- Stopped tracks are removed from RMS of later positions

Ratio of Reconstructed/Truth for No Interaction



- The shape is also consistent with what is expected
- The maximums of the ratio are reached at the most focused points along the beam line - target, TAX, collimators
- These peaks mean that the GTK reconstructs the tracks the worst at those points - but those discrepancies will be better for implementing a fit

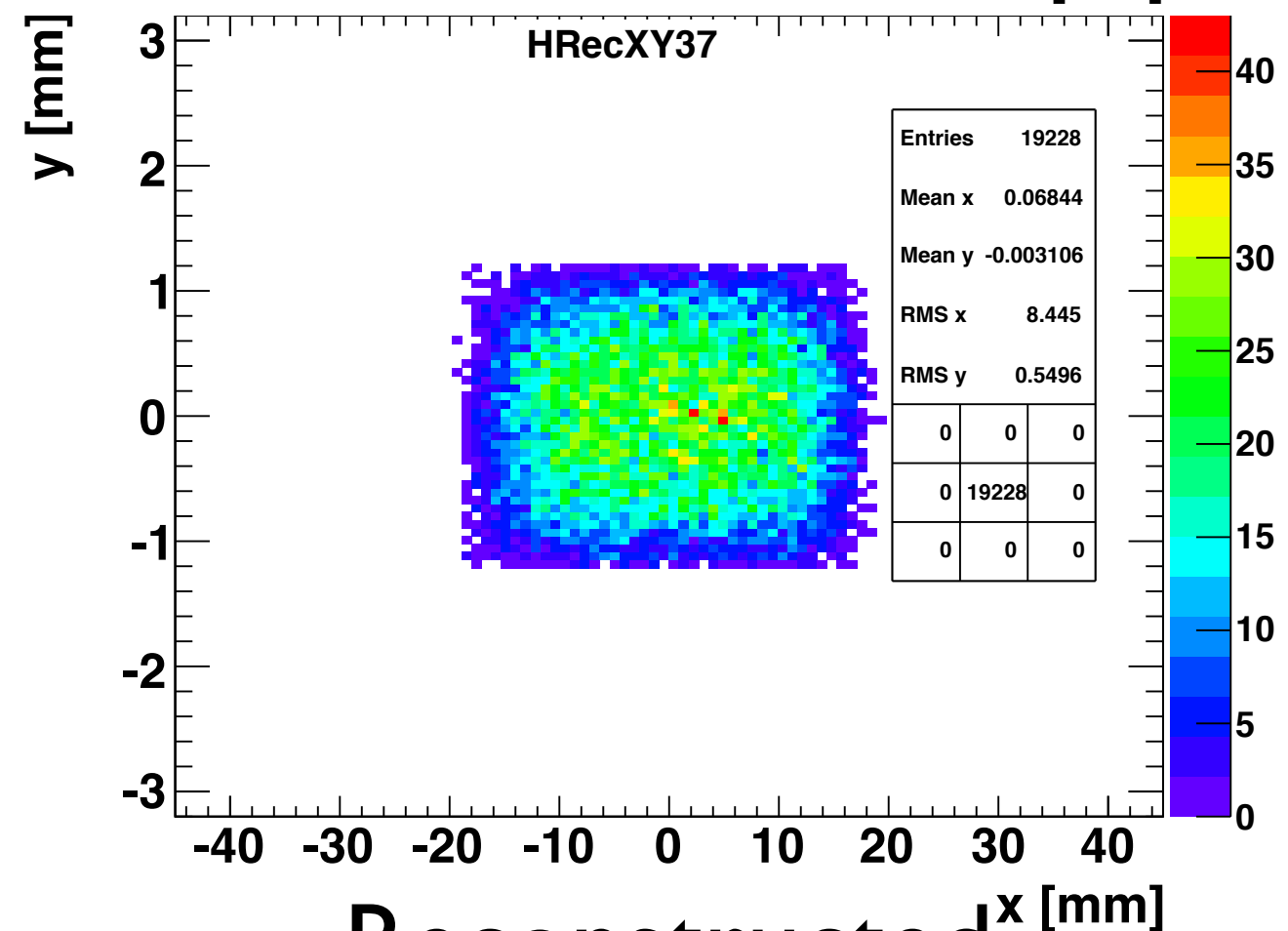
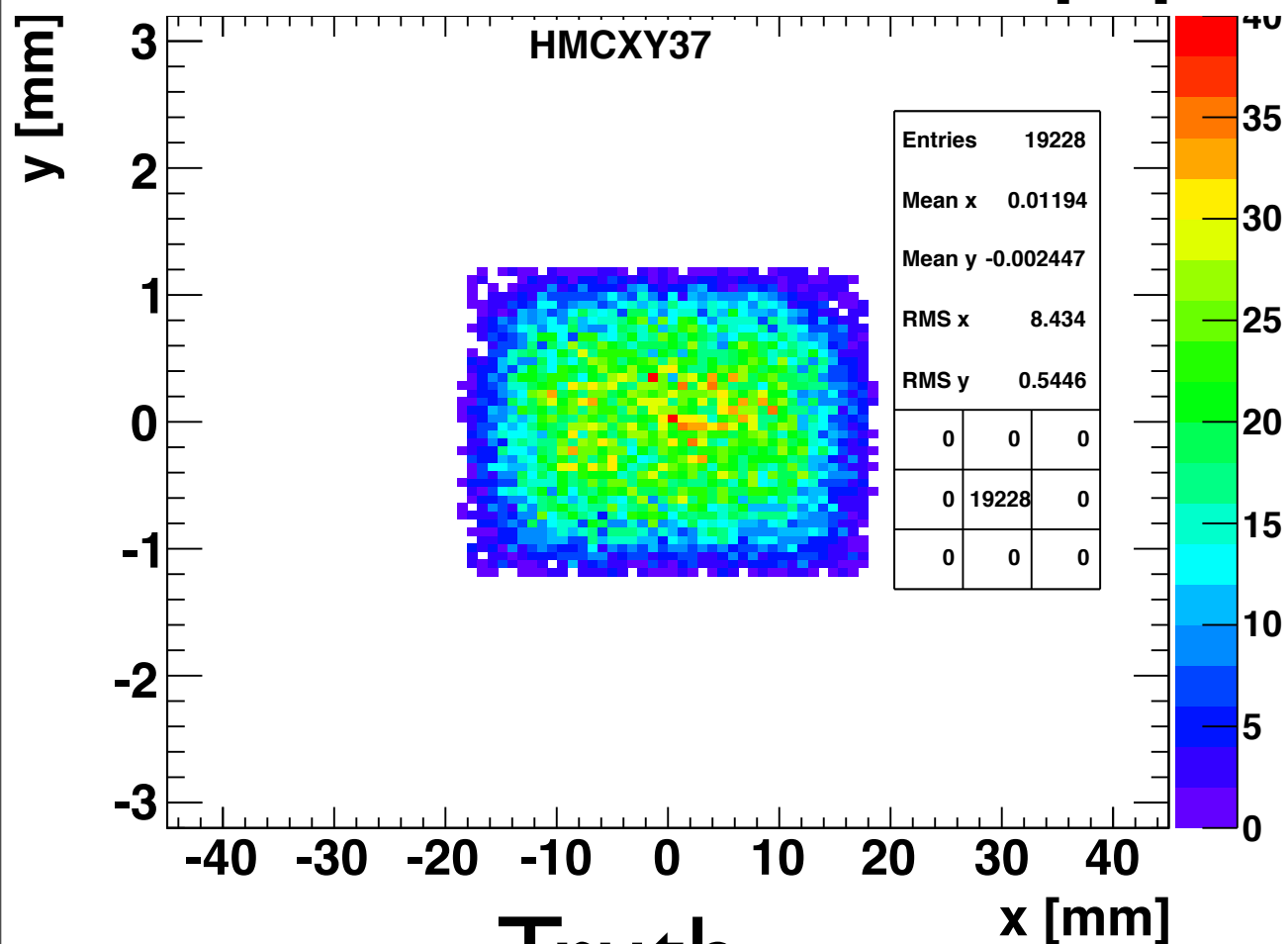
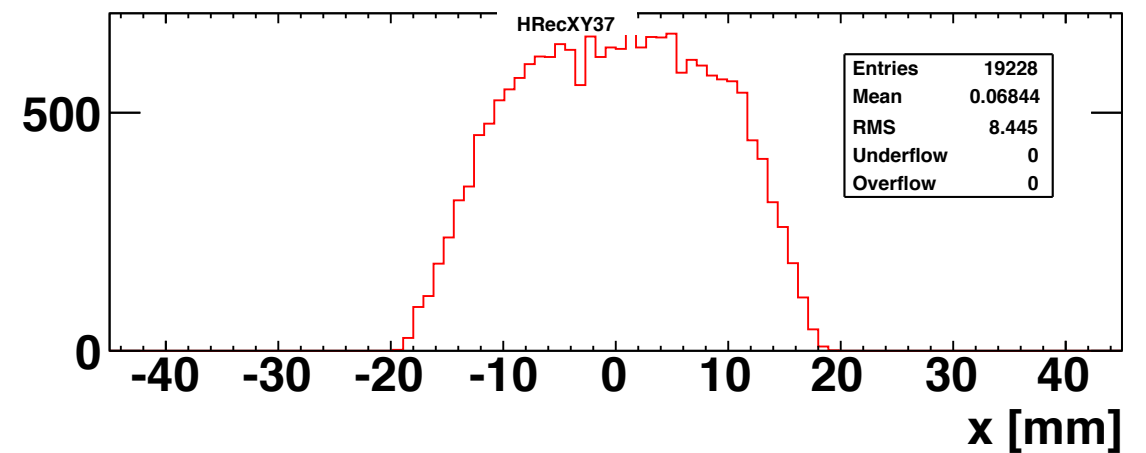
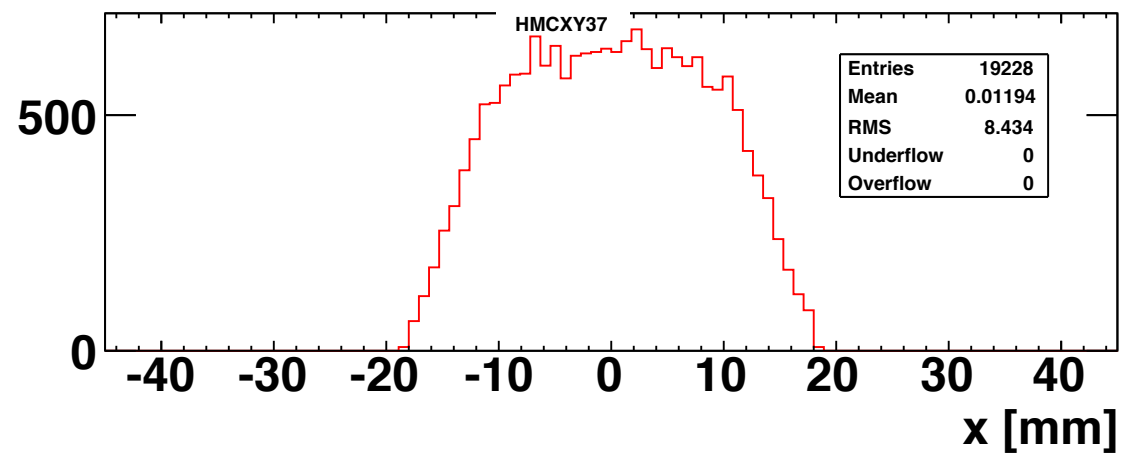
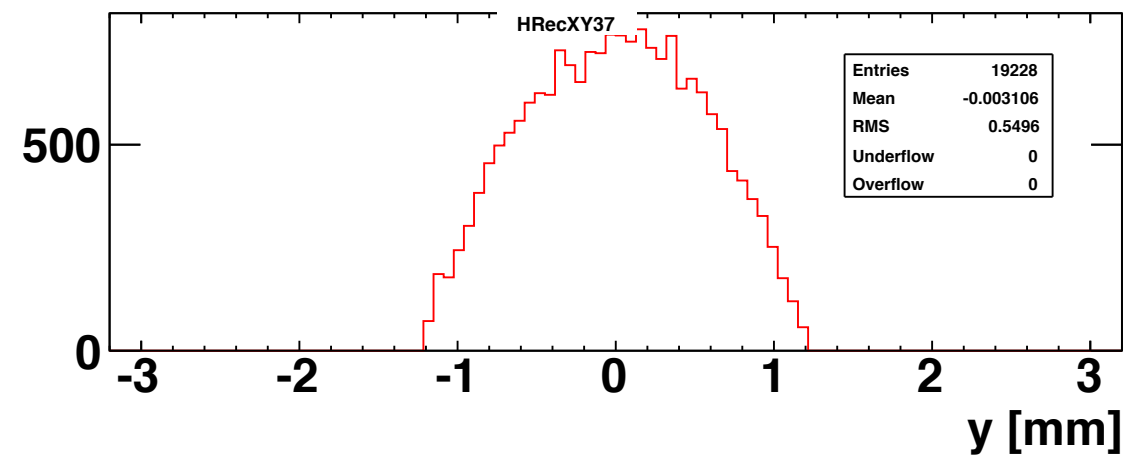
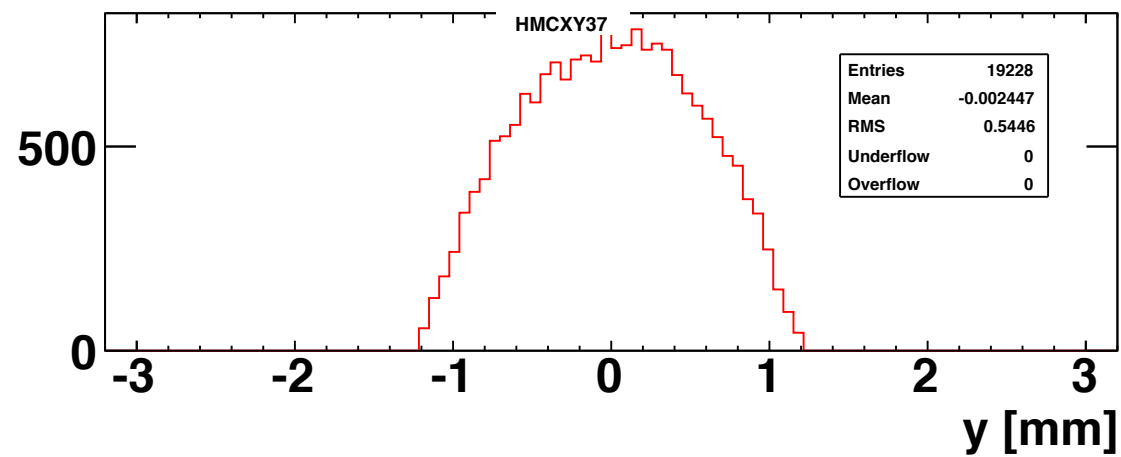
TAXs



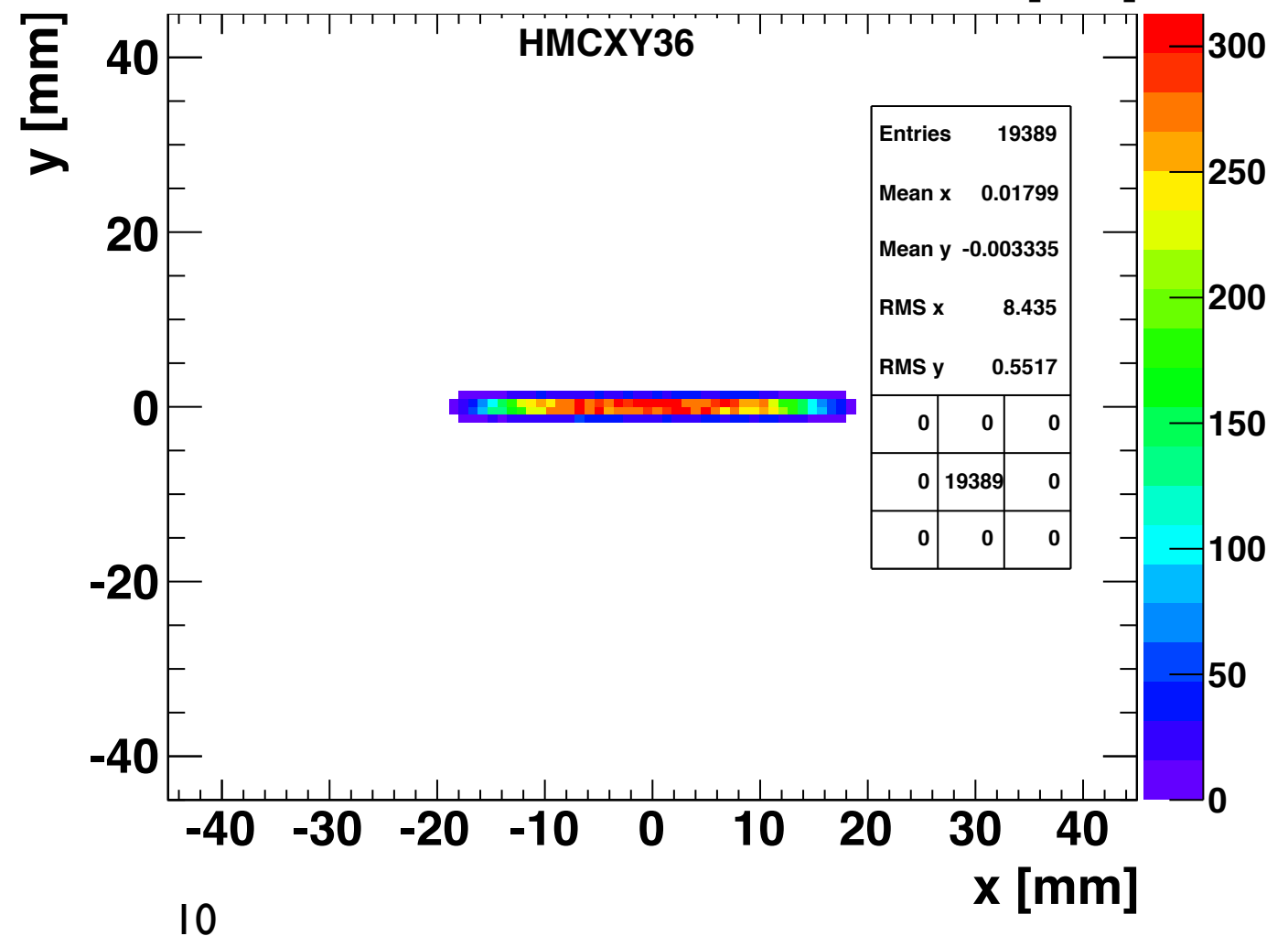
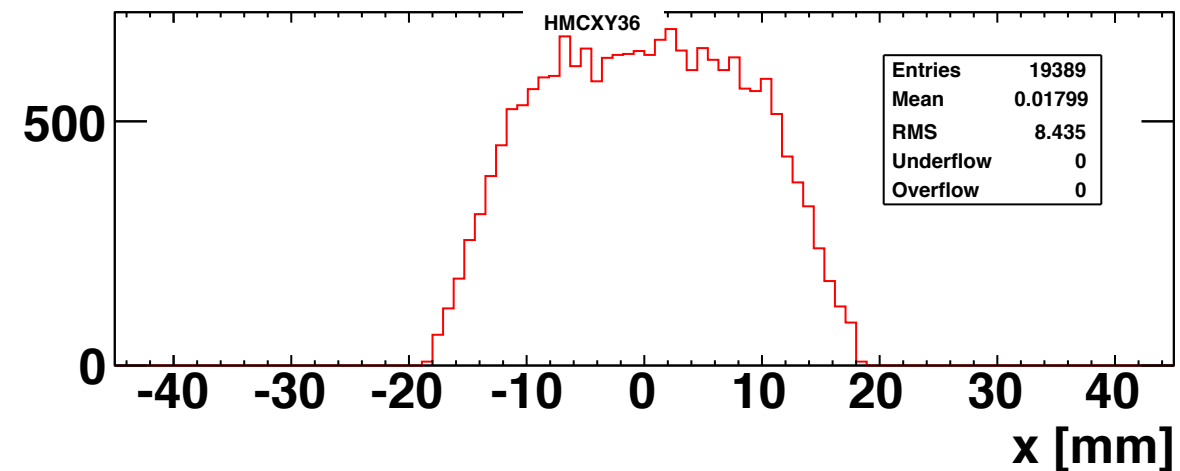
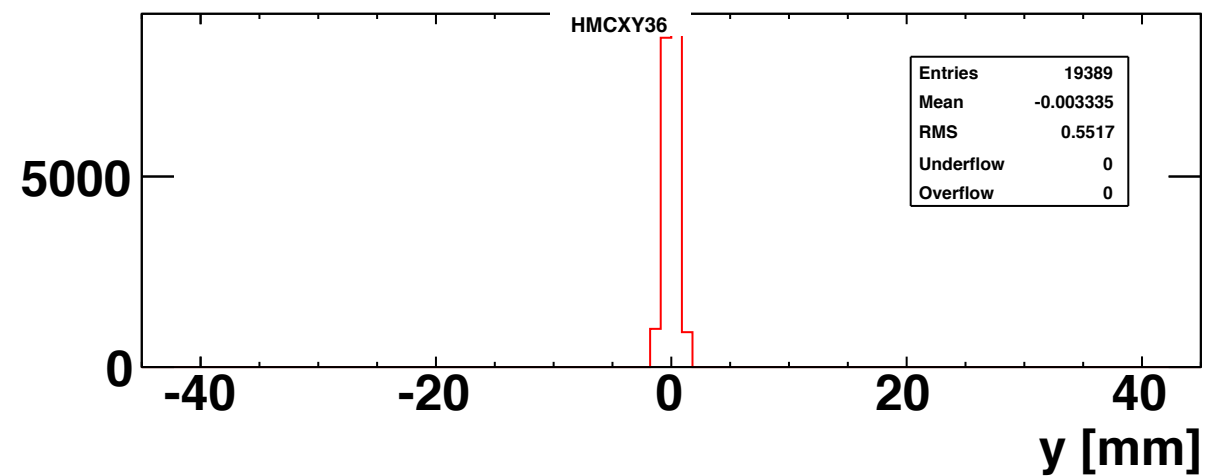
Truth

Reconstructed

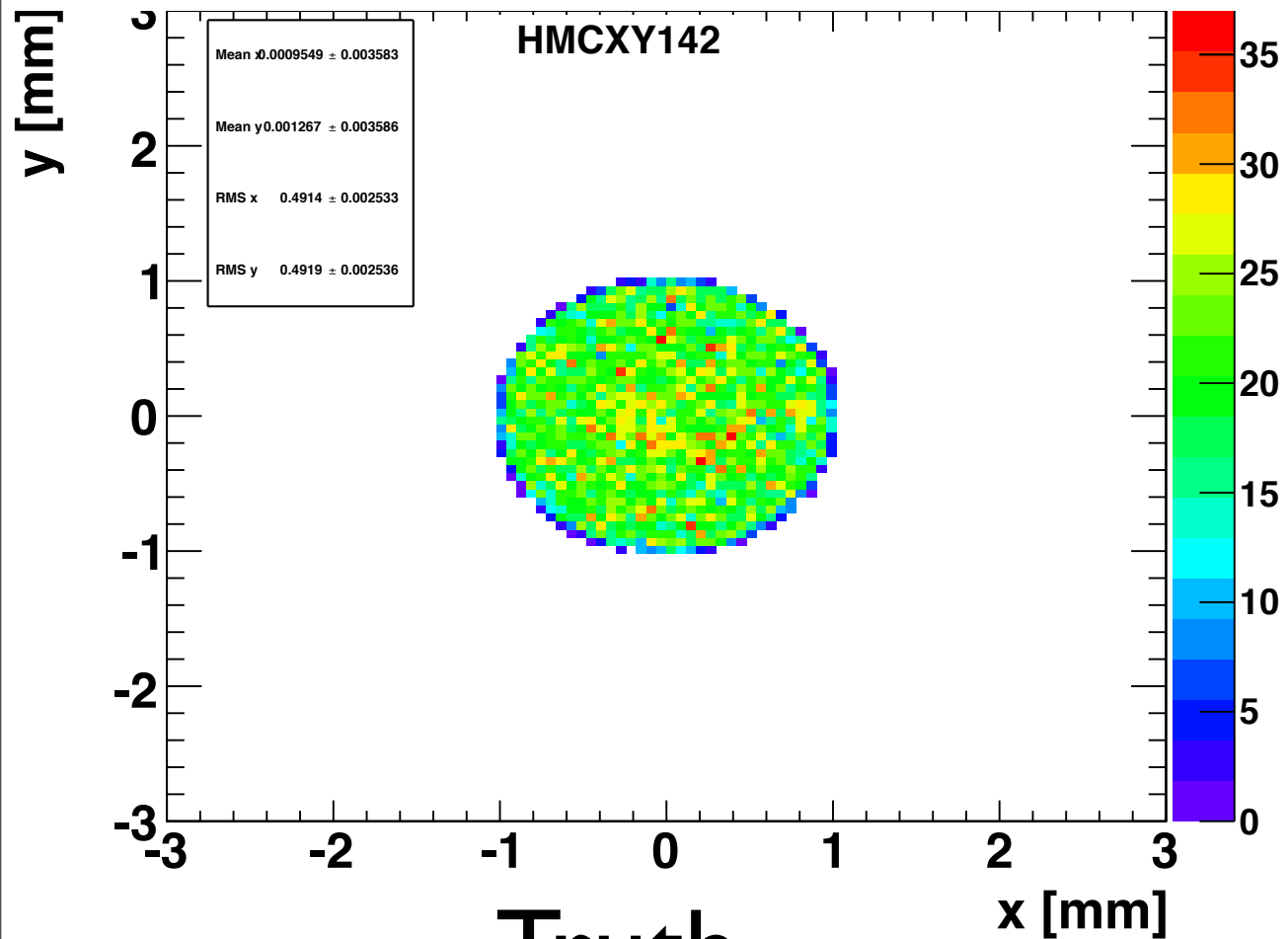
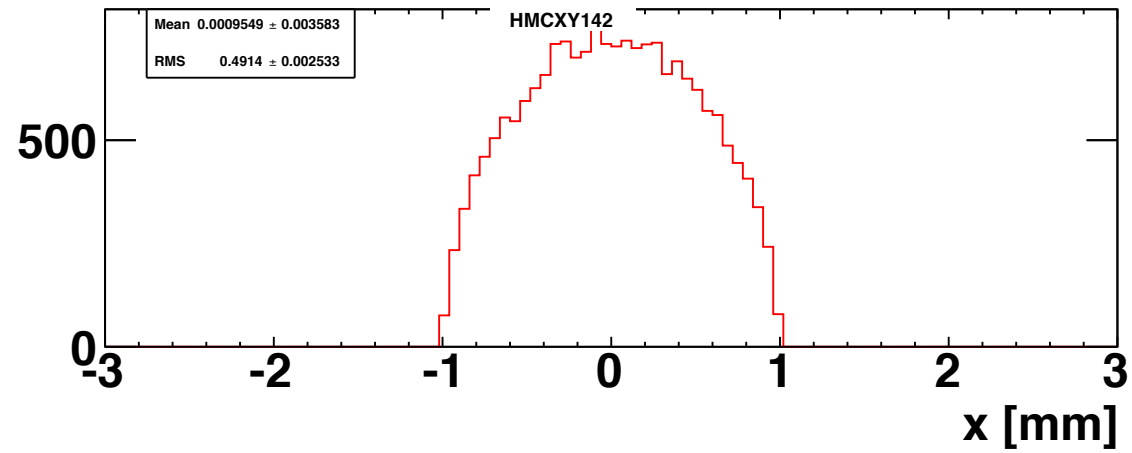
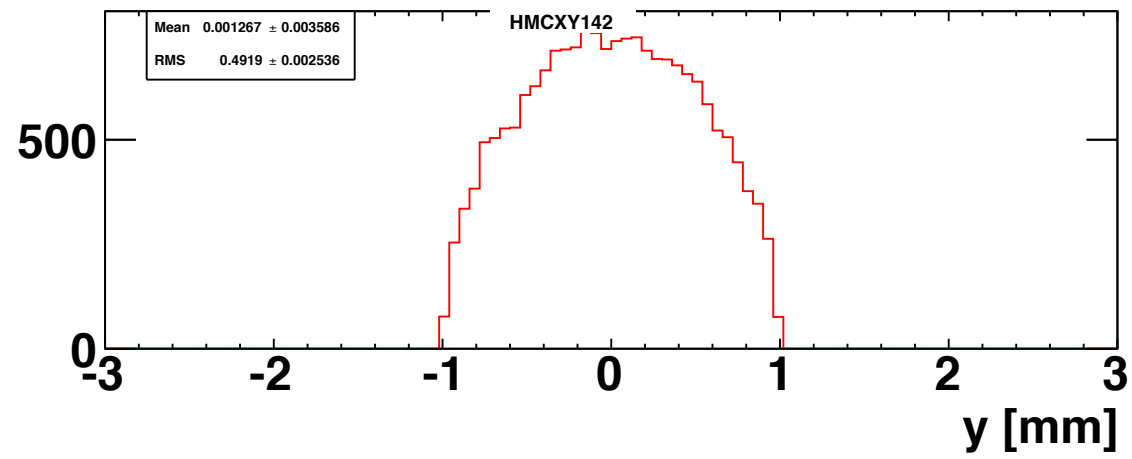
Col.
in Y



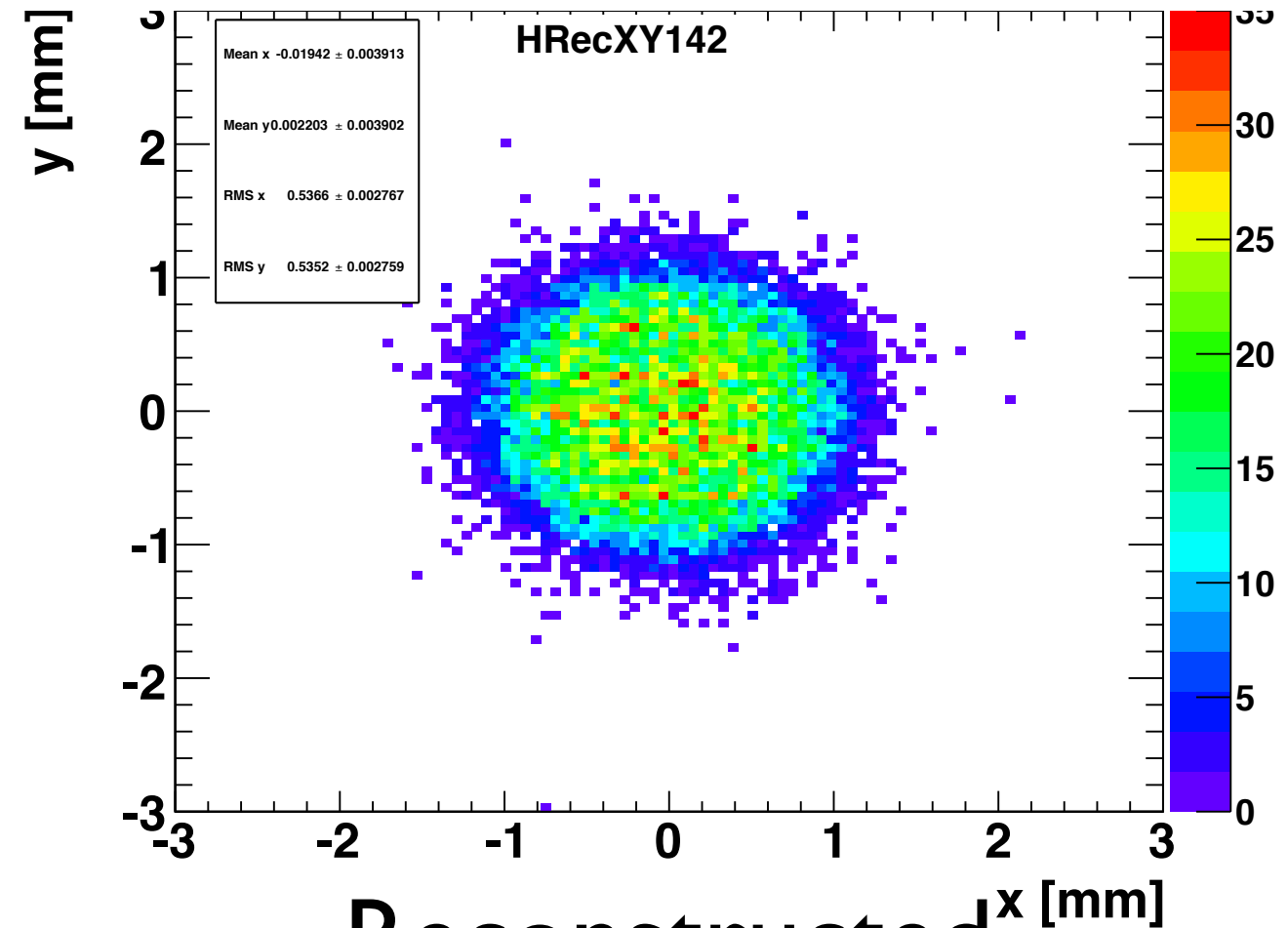
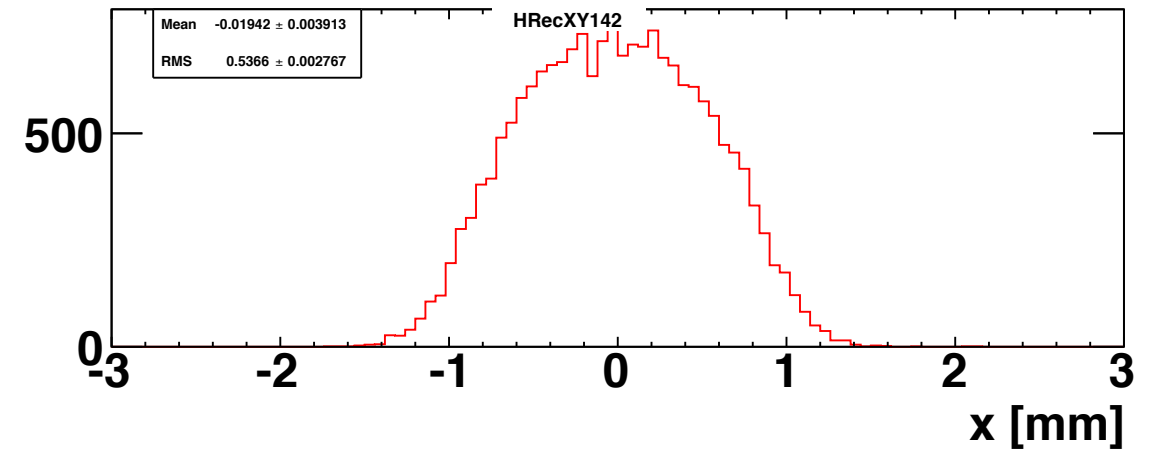
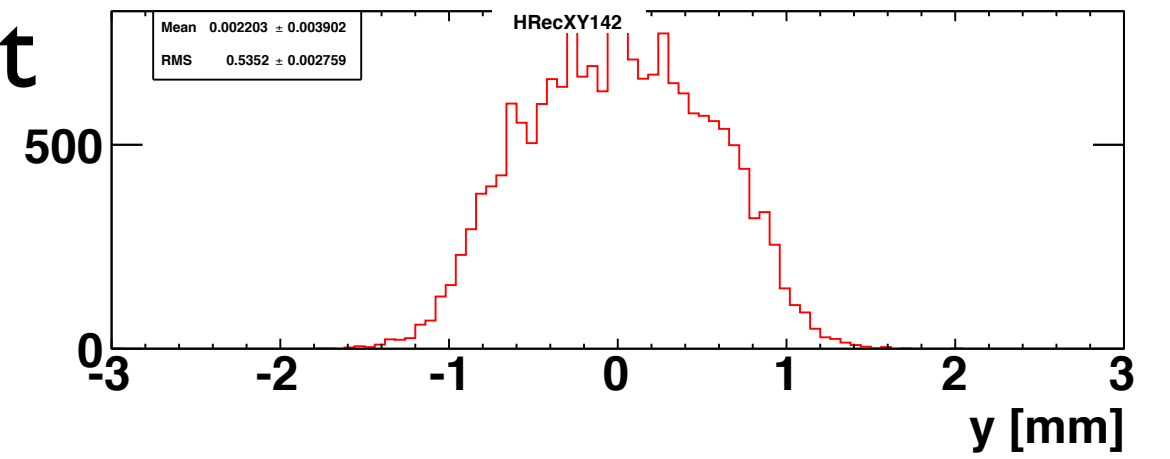
Note that the shape of the beam at ≈ 48 meters with square axes



Target



Truth

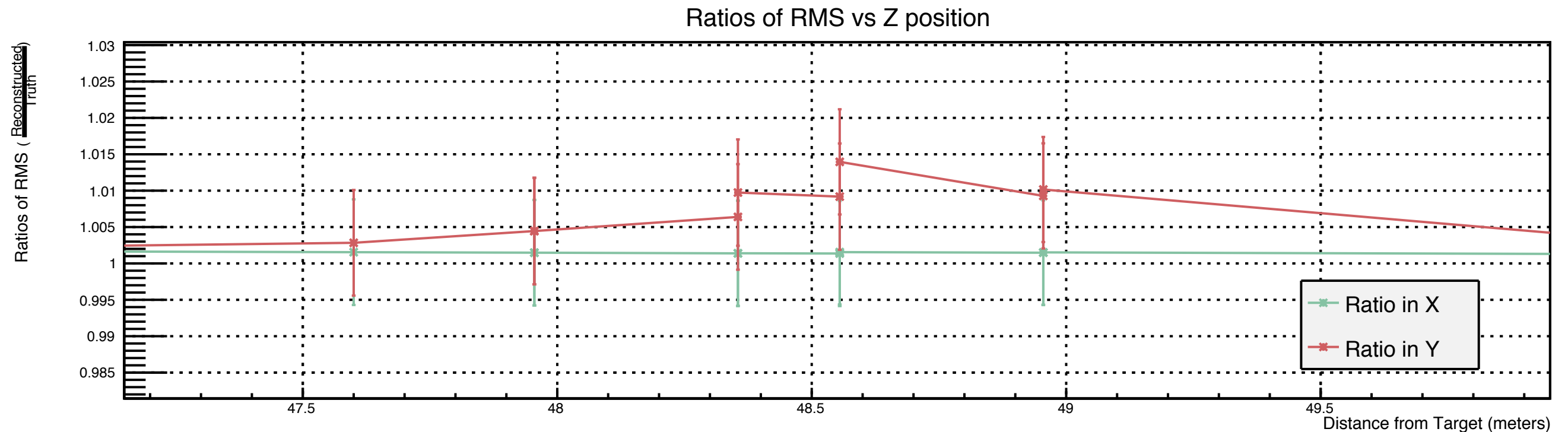


Reconstructed

||

Comparison with each
element enlarged

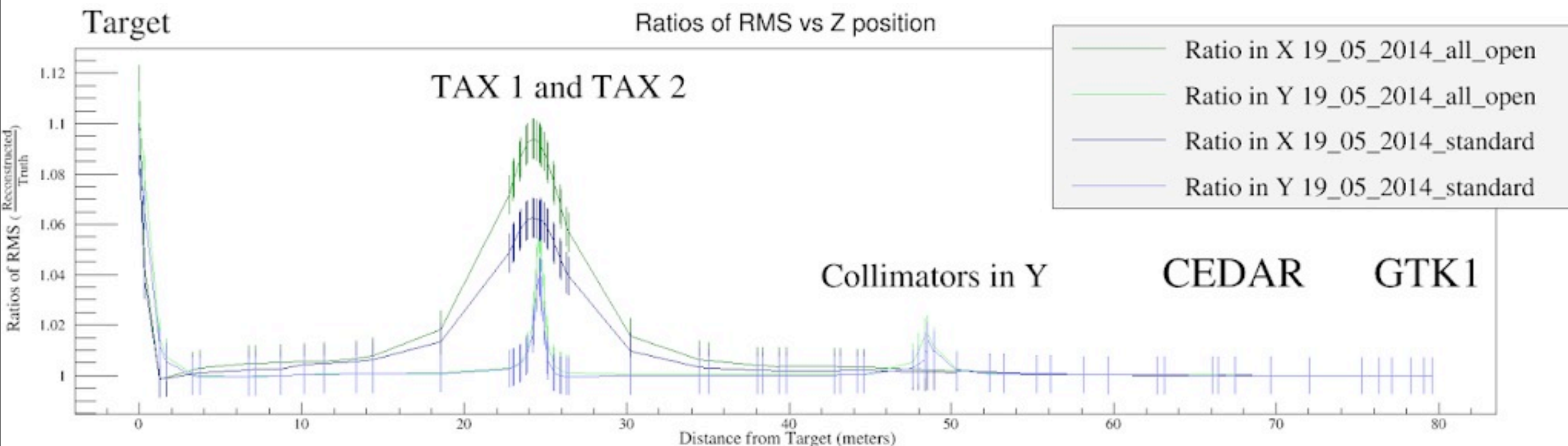
Justification for opening elements



- Zoomed in view of peak at ≈ 48 meters for no interaction
- The RMS ratio continues to increase until to focal point
- The collimators are reducing the ratio because stopped tracks are removed from the reverse propagation

All Elements Opened to 2 meter half aperture

Some efficiency is regained - particularly at the TAXs

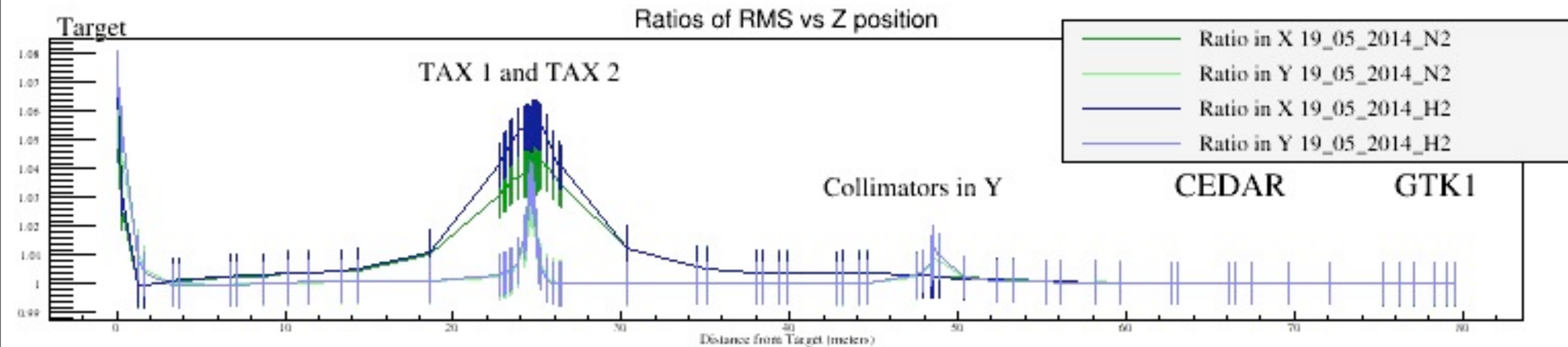


Expectation from observation with standard beam-line elements is correct. The removal of stopped tracks immediately at the given element reduces the information gained in the divergence of the beam spot.

N2 vs H2 in CEDAR

N2 now has 36 micro-radian smearing (rather than 22 micro-radians)

H2 vs N2 ratios



- The ratio is larger for H2 than N2 at both the TAX and the target
- This means that the GTK reconstructs tracks less accurately for H2 than with N2, but this is due to the fact that N2 interacts more significantly with the tracks on the way to GTK

Percent of Tracks Stopped by the target

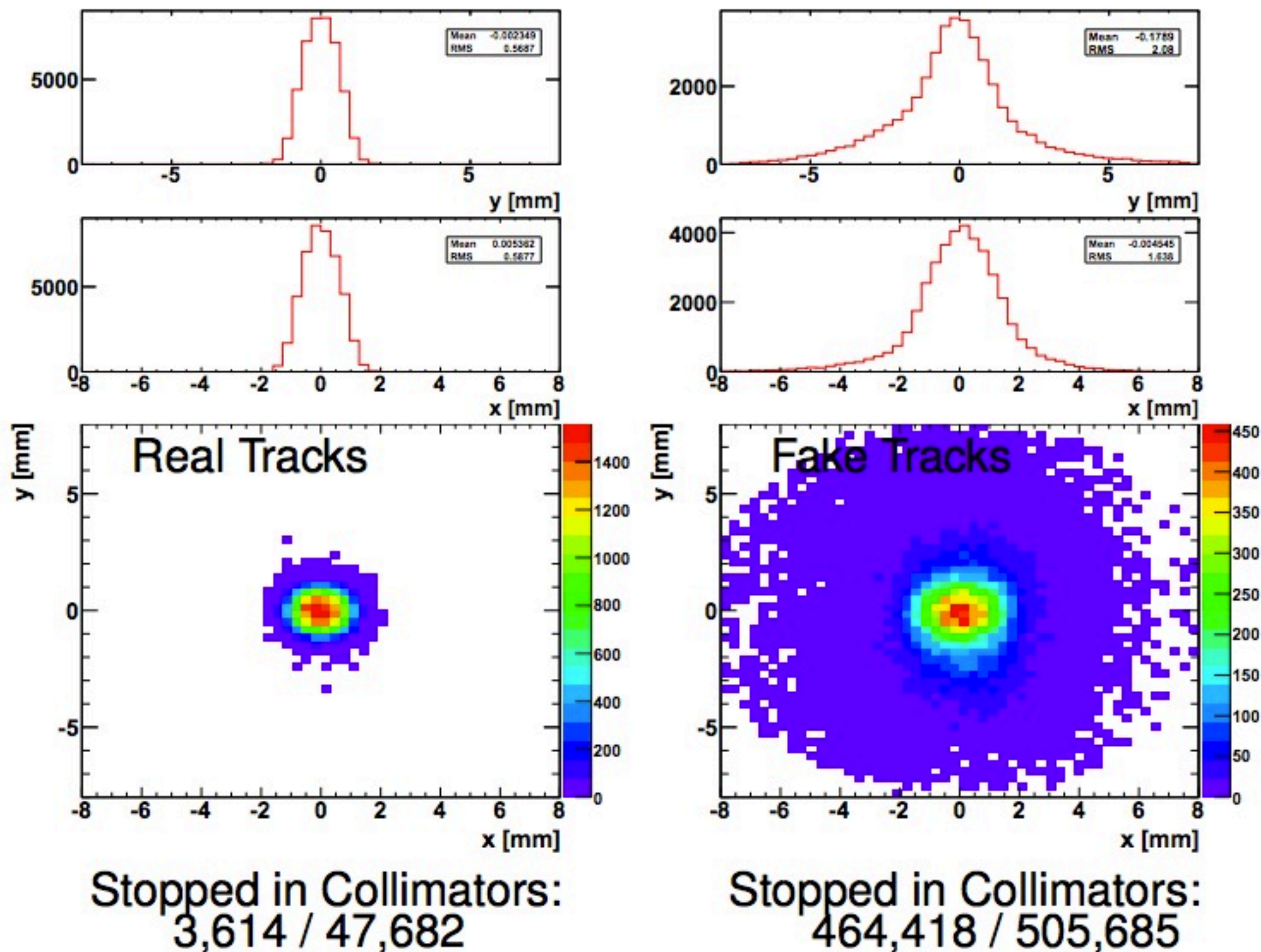
| | Truth | Reconstructed |
|----------------|-----------------|----------------|
| No Interaction | 0.06 ± 0.02 | 3.3 ± 0.1 |
| H2 | 4.9 ± 0.2 | 6.2 ± 0.2 |
| N2 (36 micro) | 10.9 ± 0.2 | 12.6 ± 0.3 |
| N2 (22 micro) | 6.7 ± 0.2 | 9.5 ± 0.2 |

Pile Up

Can the target and other elements help in removing
fake tracks?

H2-Pile Up

Recall the plots

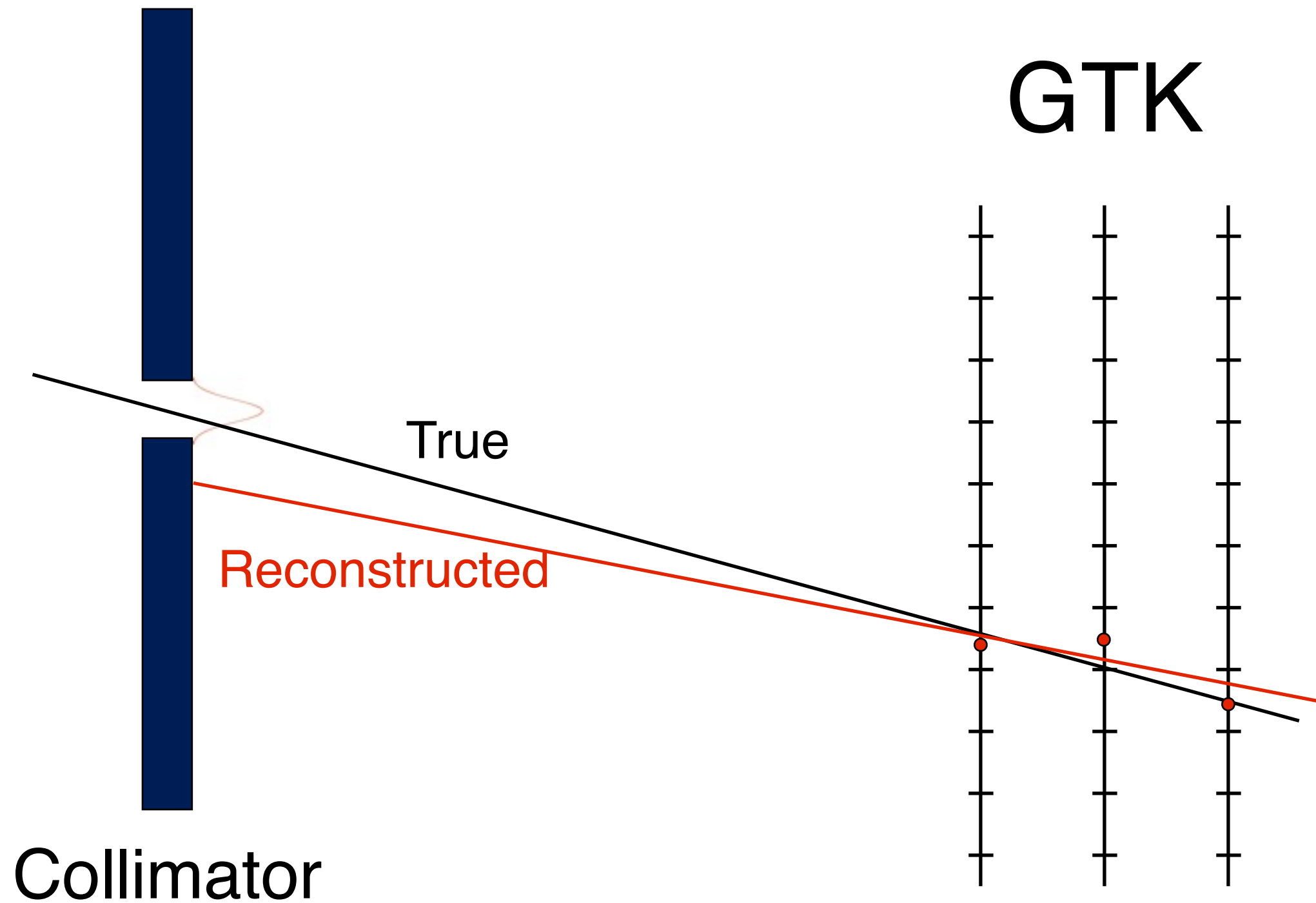


H2 vs N2 Pile Up

Percent of Tracks Stopped

| | | N2 (36) | H2 |
|-------------|------|----------------|----------------|
| TAX (90) | Real | 9.8 ± 0.2 | 3.8 ± 0.2 |
| | Fake | 89.8 ± 0.4 | 89.7 ± 0.4 |
| Target | Real | 12.6 ± 0.2 | 6.2 ± 0.2 |
| | Fake | 91.7 ± 0.4 | 91.7 ± 0.4 |

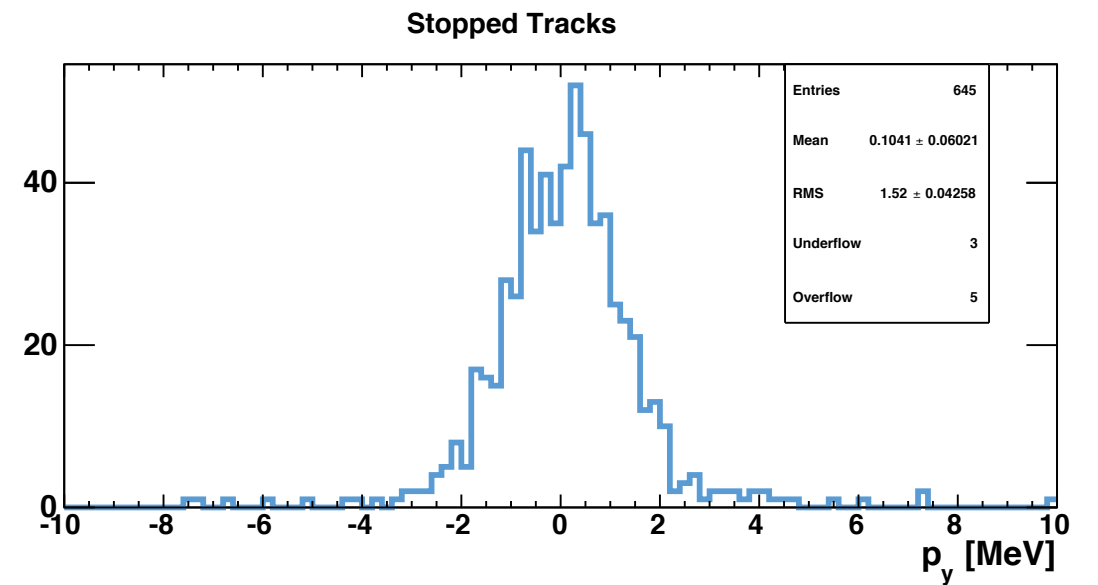
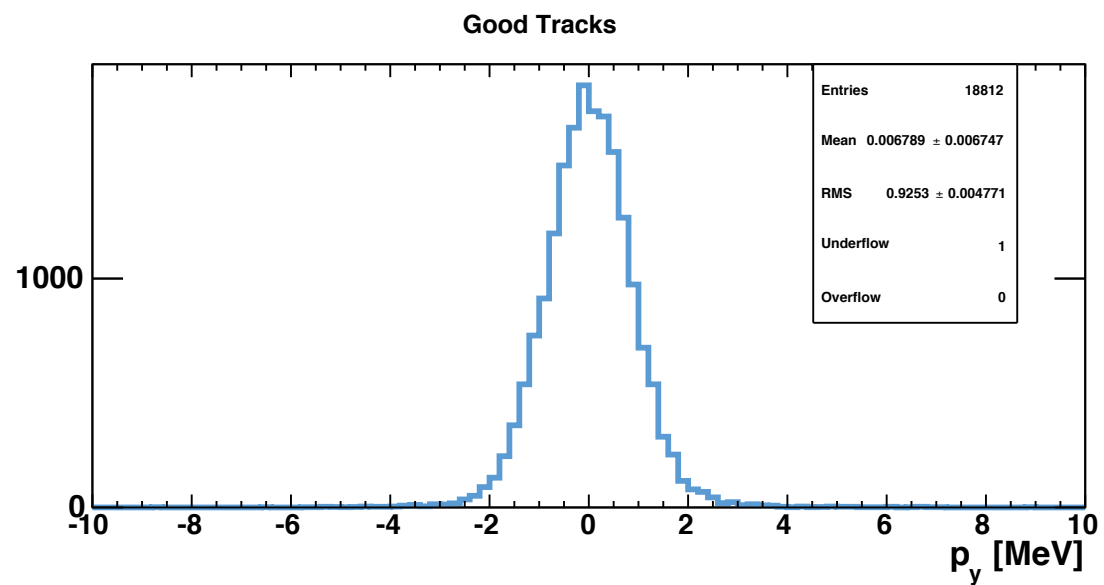
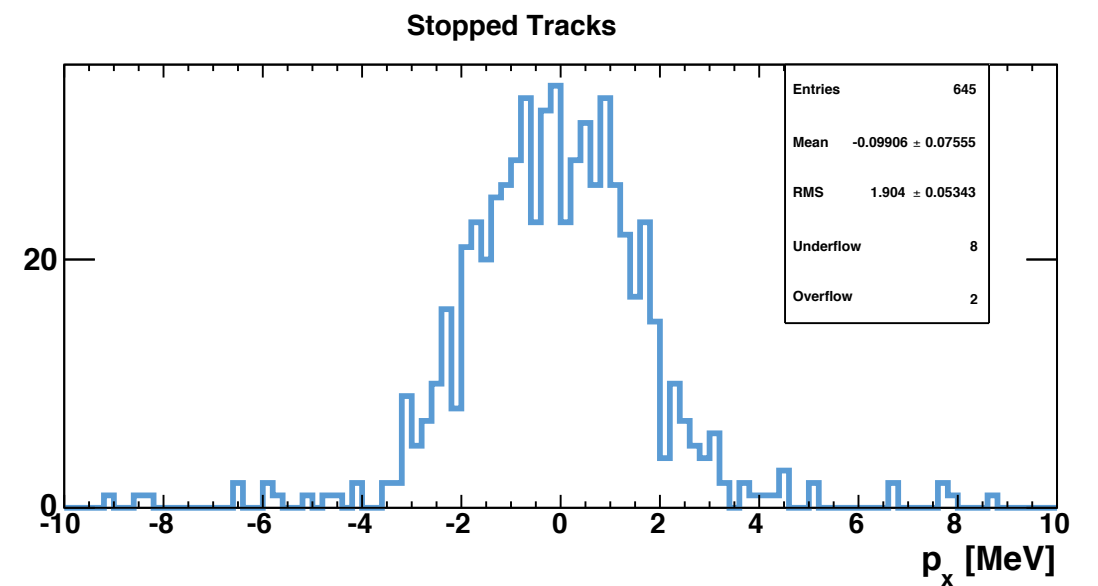
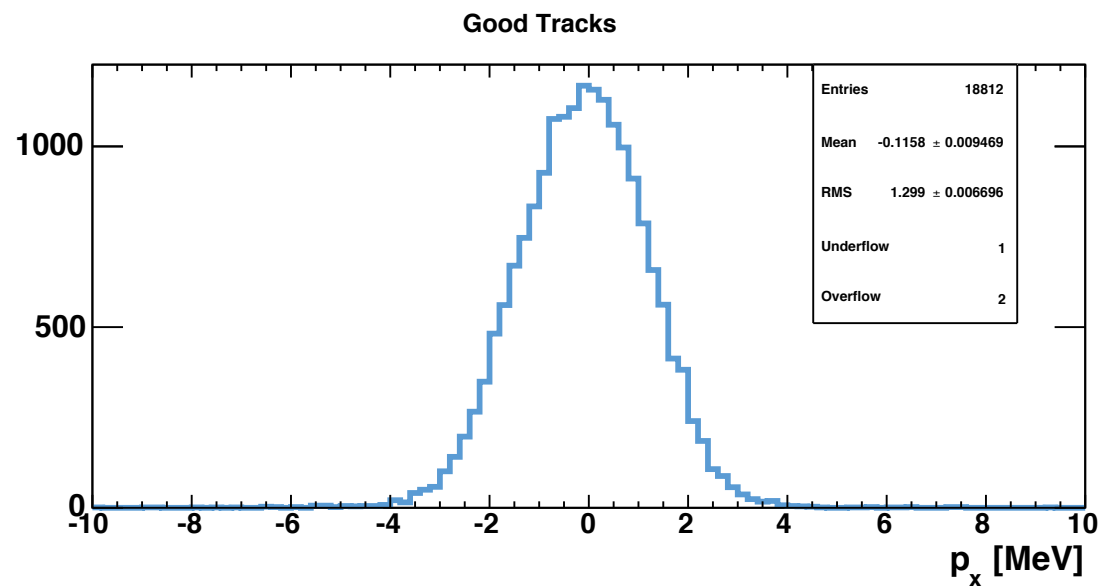
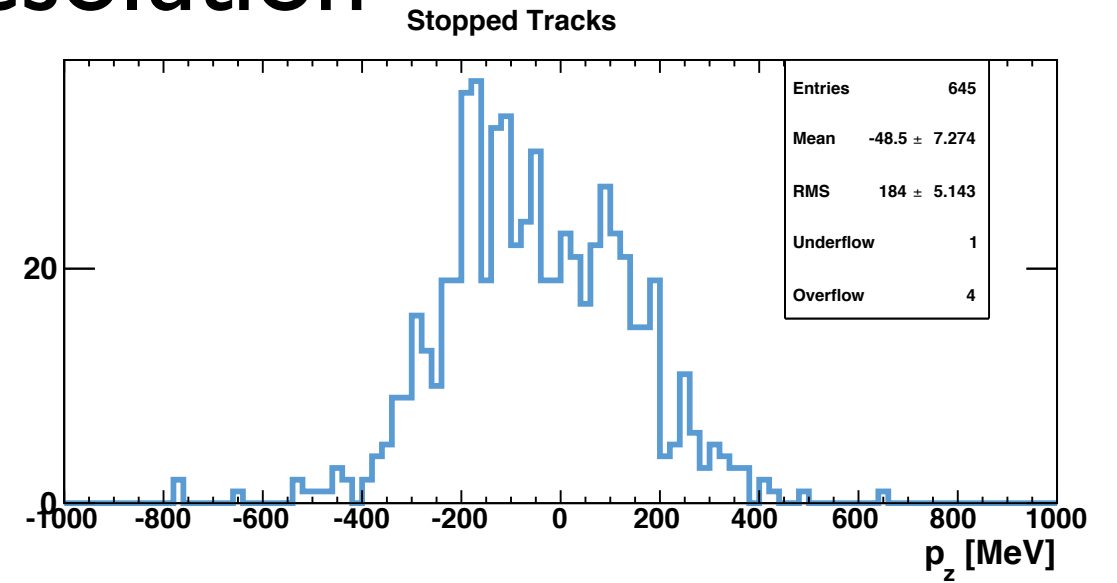
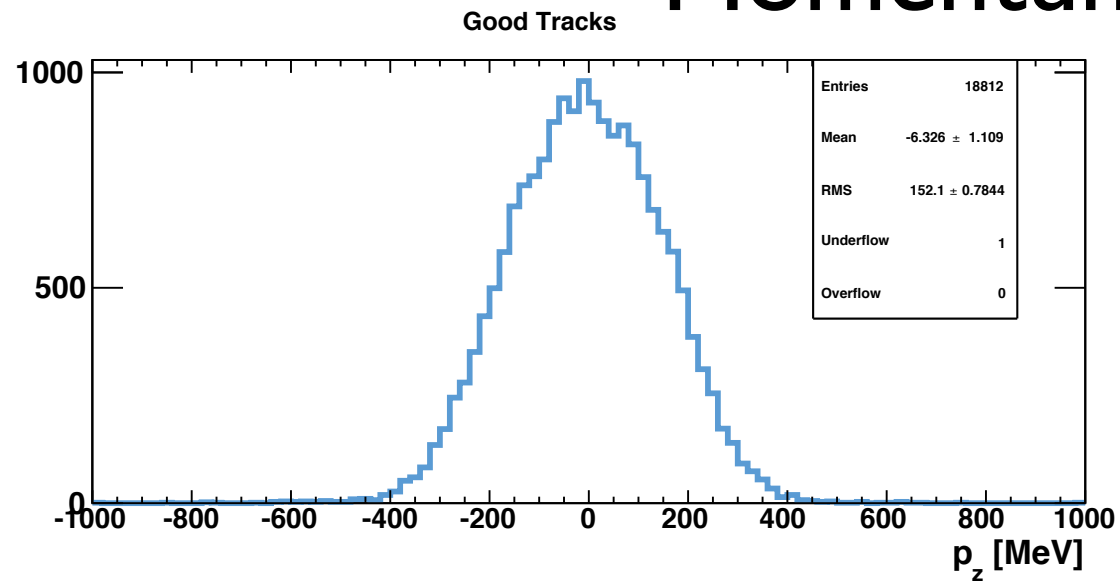
Implementing a fit



Implementing a fit

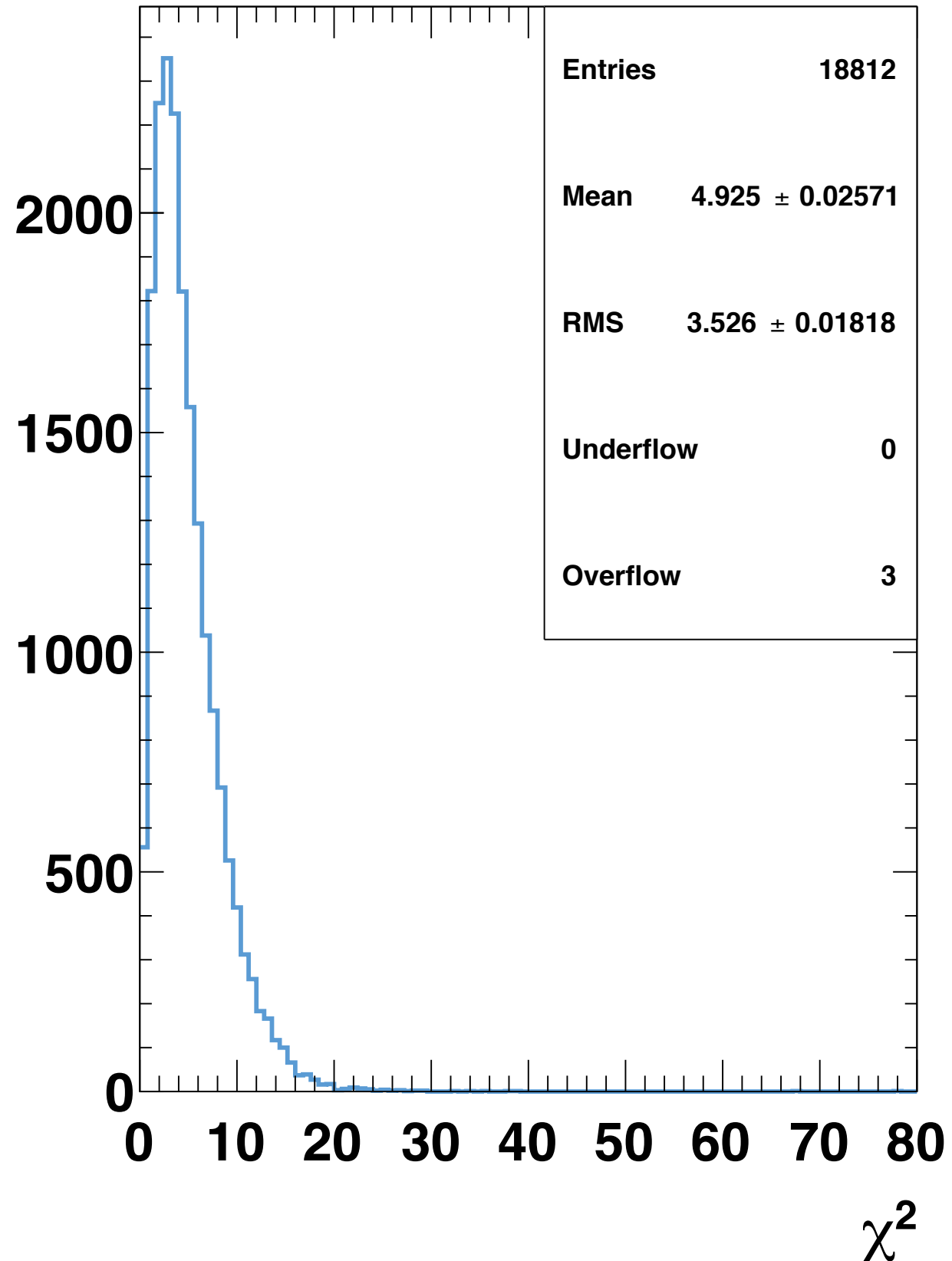
- Choose an element or elements (target, TAX, collimators) to increase the efficiency of the GTK by reducing our chi squared fit

Momentum Resolution

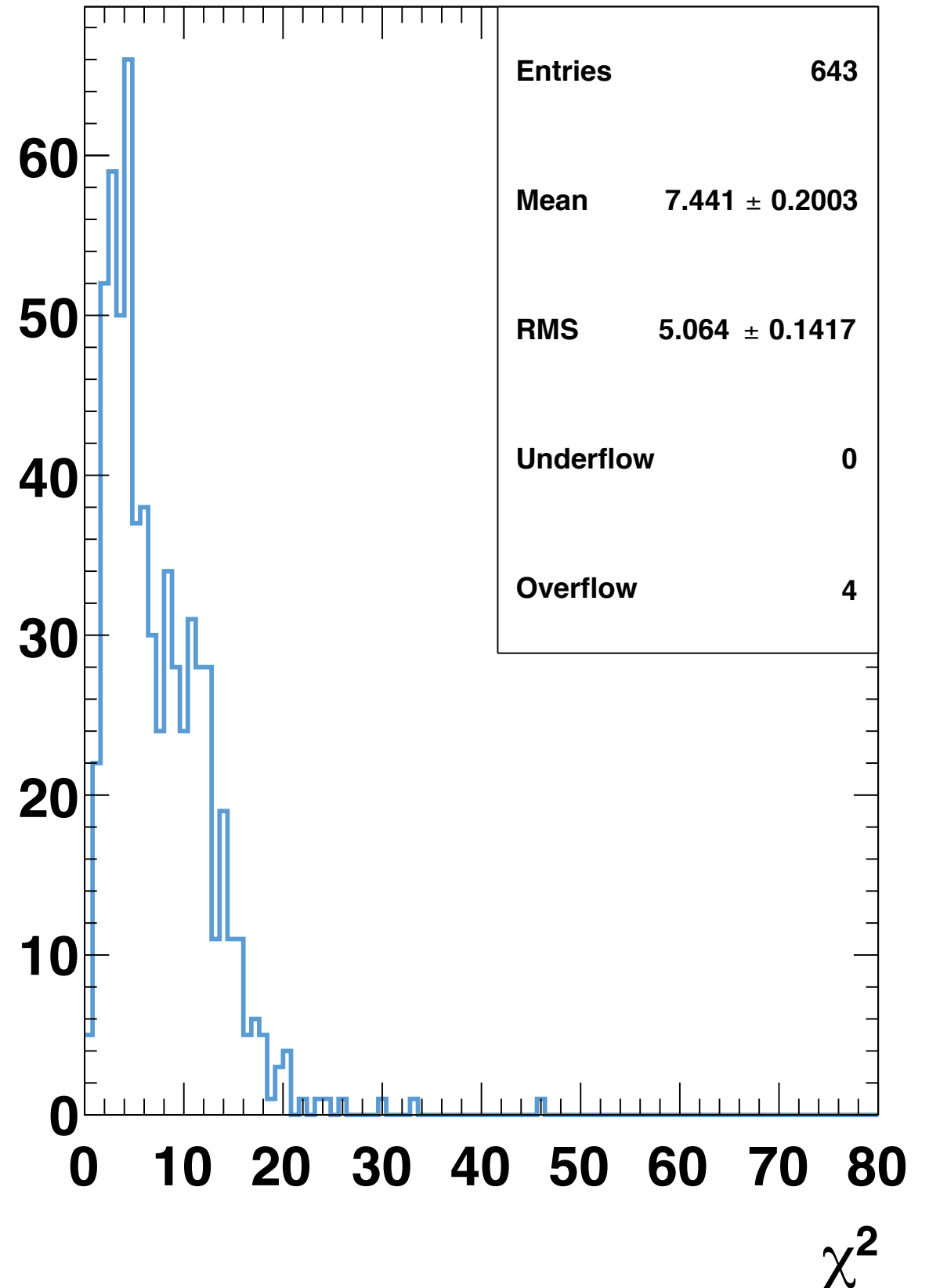


Chi Squared

Good Tracks



Stopped Tracks



Conclusion

- Most constraining elements:
 - Target and TAX
- N2 vs H2 study:
 - N2 (36) stops twice as many good tracks as H2 (11)
 - Fake track rejection is identical
- Working towards a fit